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INTRODUCTION OF PARASITES OF THE
ALFALFA WEEVIL INTO THE
UNITED STATES.¹

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LACK OF PARASITES OF THE ALFALFA WEEVIL IN AMERICA.

The alfalfa weevil (*Phytonomus posticus* Gyll.), a small snout-beetle, which in Europe, Asia, and northern Africa is occasionally injurious to alfalfa, was introduced in some unknown way into the United States near Salt Lake City some time before 1907, by which time it had locally become a serious pest. This increase in destructiveness suggested the theory that, in America, the weevil had escaped the natural and cultural influences which have controlled it in the Old World, and in a search for these controlling factors attention was early turned to parasitism.

THE SEARCH FOR PARASITES IN EUROPE.

IN 1911.

Representatives of the Bureau of Entomology who were in Europe collecting parasites of the gipsy moth began in 1911 to study the

¹ This circular summarizes the work that was done with the parasites of this particular weevil down to 1921. The writer was sent to the south of France in 1921, returning to this country in the summer of 1923. He spent many months in France studying the biology of the native parasites of the alfalfa weevil and in straightening out the somewhat confusing interrelationships between the primary and the secondary parasites. Additional material from the south of France, including additional species, will be imported during 1924.

field conditions under which the alfalfa weevil parasites live. They also undertook to identify the species and to learn their life histories. The beneficial character of the pteromalid, eupelmine, and mymarid egg parasites and of the larval parasite *Bathyplectes curculionis* Thoms. was established the first year, and some experimental shipments were made. Of these, seven lots of green stems containing parasitized eggs and three lots of cocoons were received in Utah, and the parasites which issued from them were released there.

IN 1912 AND 1913.

In 1912, as a result of the continued study of these forms and others, about 15 species of primary and secondary parasites began to be considered as important. A careful survey of Italy, Sicily, Switzerland, and southern France, involving the collection, dissection, and rearing of large numbers of the host and its parasites and the determination of the rate of parasitism in each locality, was begun in 1912 and continued in 1913. While the principal purpose of these investigations was to learn where parasites for shipment could be collected to advantage, they showed incidentally that a surprisingly small amount of parasitism was the rule, the highest average for any locality being 25 per cent in the eggs and 12.5 per cent in the larvae, while the lowest average was a fraction of 1 per cent in the eggs and 3.16 per cent in the larvae.

Material was shipped from Europe to the United States in 1912 amounting to about 45,000 stems containing egg masses of the weevil, 60,350 weevil cocoons, some of which were parasitized, and 3,104 cocoons of *Bathyplectes*, mostly of the species *curculionis*.

In 1913, 10 shipments of egg-parasite material were received in Utah, besides 21 shipments of larval-parasite material, comprising 139 boxes containing altogether about 27,800 weevil larvae, and 6 lots of cocoon material probably containing 50,000 cocoons. The specialists who studied these importations established the list of species given below and determined the host relations of the more important ones.

LIST OF SPECIES STUDIED.

HYMENOPTERA REARED FROM EGG MATERIAL.

Anaphoidea luna Gir., a mymarid parasite of the egg.

Eupelmus excavatus Dalm., a eupelmid parasite of the egg; external feeder.
Pteromalids: Four or five species, including—

“ Pteromalid A,” an external parasite of the egg.

“ Pteromalid B” (*Spintherus* sp.?), a parasite of the egg.

“ Pteromalid C,” host unknown.

Eulophids: One or two species, undetermined, hosts unknown.

HYMENOPTERA REARED FROM LARVAL MATERIAL.

Bathyplectes curculionis Thoms., a parasite of the larva.

Bathyplectes corvina Thoms., a parasite of the larva.

Bathyplectes tristis Grav., a parasite of the larva of *Phytonomus posticus* Gyll. and *Hypera punctata* Fab.

Mesochorus nigripes Ratz., a parasite of *Bathyplectes*.

Eulophid, possibly a parasite of the larva.

HYMENOPTERA REARED FROM COCOON MATERIAL.

(In addition to the first four of the previous section, which were also reared from cocoons.)

- Aenoplegimorpha micator* Grav., a cryptine parasite of the prepupa.
Hemiteles gracilis Grav., a cryptine parasite of the prepupa.
Spilocryptus pumilis Kriechb., a cryptine parasite of the prepupa.
Itoplectis maculator Fab., an ichneumonine parasite of the pupa.
Dibrachoides dynastes Först., a pteromalid parasite of the prepupa and pupa.
 Eulophid, undetermined, a parasite of *Dibrachoides dynastes* Först.
Gelis sterenii Grav., a geline parasite of *Bathyplectes*.
Dibrachys boucheanus Ratz., a pteromalid parasite of *Bathyplectes*.
Eupteromalus sp., a native pteromalid parasite of *Bathyplectes*.
 Ichneumonid, undetermined, a parasite of either the cryptines above or
Bathyplectes tristis.

In addition to these parasites there were recovered from the imported stems several species belonging to the injurious rhynchophorous genus *Apion*, together with several braconids, probably parasitic upon them.

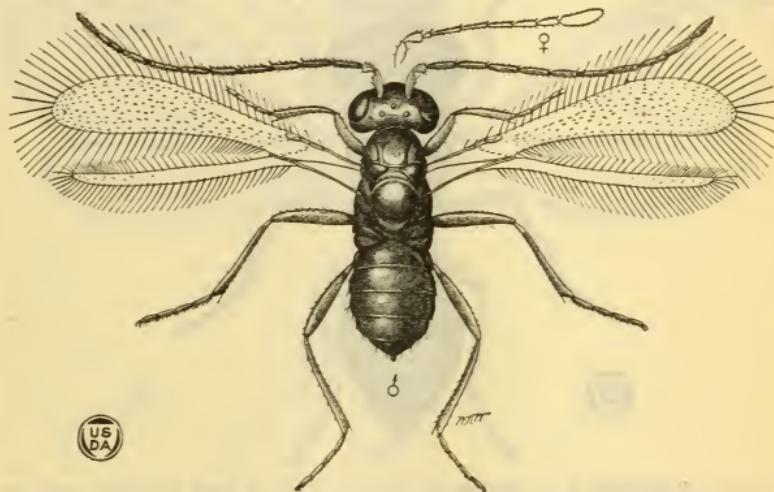


FIG. 1.—*Anaphoidea luna*, a mymarid egg parasite of the alfalfa weevil: Adult male; antenna of female above and to the right. Greatly enlarged. (Webster.)

THE MORE IMPORTANT IMPORTED PARASITES.

PRIMARY PARASITES.

Anaphoidea luna Gir.

Anaphoidea luna (fig. 1) was among the first of the parasites to be imported. Three hundred and forty-five individuals were liberated in 1911, many in 1912, and 1,150 females and 245 males in 1913, when the issuance of the adults continued from May 13 to June 11, culminating between May 22 and June 6.

Eupelminus excavatus Dalm.

Eupelminus excavatus was liberated between June 3 and November 25, 1913, to the number of 430 males and 471 females. Its issuance occurred principally after October 3, substantiating the observations made in Italy that the larvae of this species feed upon egg masses

throughout the early part of the year and then usually aestivate, emerging and probably ovipositing in the fall.

"Pteromalid A."

"Pteromalid A" (fig. 2), at present undetermined, was proved to be a predator upon the eggs of the weevil by T. H. Parks and W. F. Fiske in 1911.²

That year, 460 were placed in field cages and later released, while in 1913, 550 males and 430 females were liberated directly in the fields. The height of the issuance of this species occurred about June 1 in the latter year, but emergence probably occurred somewhat earlier in 1911, as it was completed by June 8.

Dibrachoides dynastes Först.

Dibrachoides dynastes (fig. 3), an external feeder upon the prepupa and pupa of the alfalfa weevil, was released to the number of

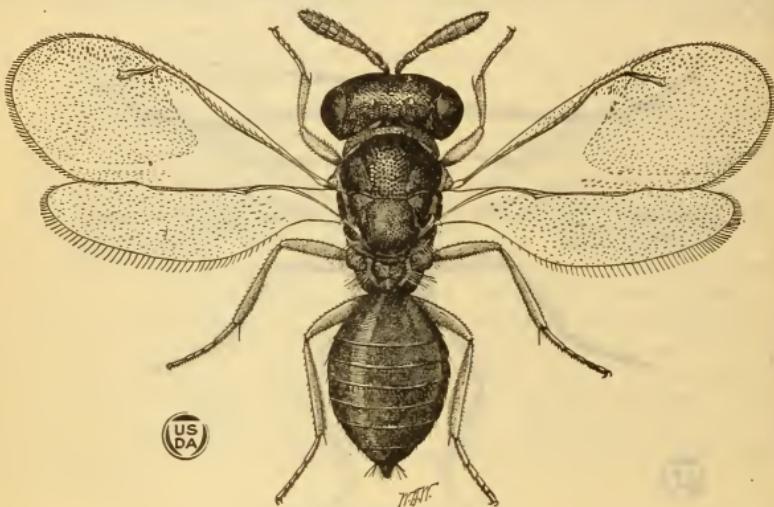


FIG. 2.—"Pteromalid A," a pteromalid the larva of which feeds externally upon the eggs of the alfalfa weevil: Adult female. Greatly enlarged. (Webster.)

230 in 1911 and 1,389 in 1913. In 1913, the issuance from European material extended from May 22 to June 21. In confinement this species continues to breed as long as the temperature is mild and host material is available. In 1911, adults of five generations were bred in this way between May and September.

Bathyplectes curculionis Thoms.

Bathyplectes curculionis (fig. 4), the commonest of the larval parasites, has received much attention throughout the investigation and, with the exception of *Aenoplegiomorpha micator* Grav., is the only imported parasite of the alfalfa weevil which has become established in America. In 1911, over 7,000 weevil cocoons, in which parasitism by this species ranged from 2 per cent to 10 per cent, were shipped, and from these 40 adults presumably of this species

² Webster, F. M. Preliminary Report on the Alfalfa Weevil. U. S. Dept. Agr. Bur. Ent. Bul. 112, 47 p., 27 fig., 13 pl. 1912. (See p. 35, 36.)

were liberated. In 1912 there were imported 787 cocoons of this species, 1,656 parasite cocoons, mixed but mostly of this species, and 54,250 weevil cocoons, some of which were parasitized, from which most of the issuance was released. From the importations of 1913, which were in the form of weevil larvae and cocoons, a total of 1,335 adult *Bathyplectes*, of which 827 were females, were reared and liberated. Part of these parasites were from overwintering or second-generation cocoons and did not emerge until 1914.

The introductions of 1911 were made near Sandy, Utah, those of 1912 and 1913 at Salt Lake City, and those of 1914 at Kaysville and at Ogdens. In 1914, outside the fields where it had been released after 1911, *Bathyplectes* was found only in small numbers, and not at all a few miles away, but in 1916, in the Salt Lake region, the rate of parasitism within an 8-mile radius was 22.5 per cent and the

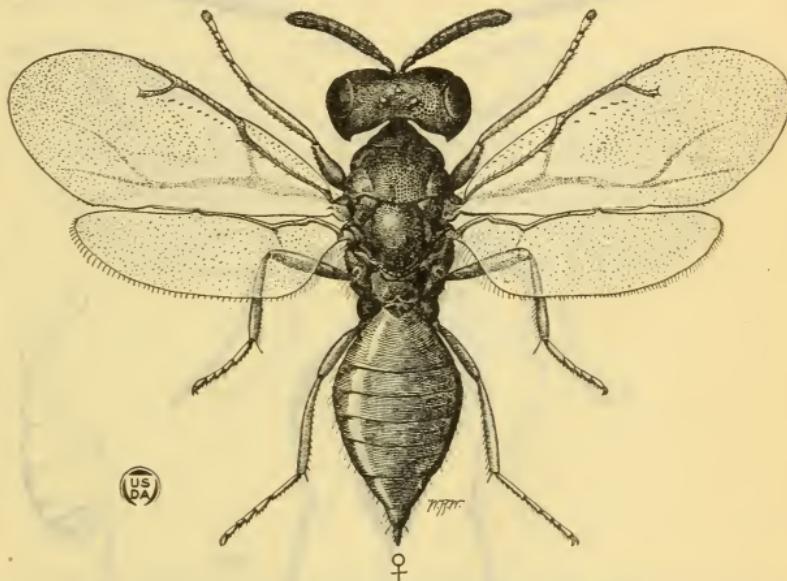


FIG. 3.—*Dibrachoides dynastes*, a pteromalid parasite of the prepupa and pupa of the alfalfa weevil: Adult female. Greatly enlarged. (Webster.)

insect could be found in the Weber Valley, 30 miles to the east. In 1917 the radius of its known territory was 45 miles, in 1919, 120 miles, and in 1920, 230 miles. Its area is now nearly coextensive with the area occupied by the weevil, and in the older sections it destroys more than 90 per cent of the larvae. Introductions of this parasite into the isolated weevil colonies were made with the cooperation of the State experiment stations in Colorado in 1918 and in Nevada in 1921.

SECONDARY PARASITES ATTACKING BATHYPLECTES.

The more troublesome of the parasites of *Bathyplectes curculionis* are *Mesochorus nigripes* Ratz., *Gelis sterenii* Grav., *Dibrachys boucheanus* Ratz., and *Eupteromalus* sp. (fig. 5). The first not only superficially resembles its host, but issues from the latter's cocoons

at the same season and in nearly equal numbers with it, according to the Bureau of Entomology's experience with European material; and therefore constant vigilance is necessary in artificial colonization to prevent its release. *Gelis stevenii* was present in 24 per cent of some lots of imported *Bathyplectes* cocoons, and a similar if not identical species has been recovered in Utah. *Eupteromalus* sp., the most common of these secondary parasites in Utah, is probably a native species, as nothing identical has been taken from European material. *Dibrachys boucheanus* and other pteromalids at present undetermined issued from many *Bathyplectes* cocoons, but are apparently less pernicious than any of the foregoing species.

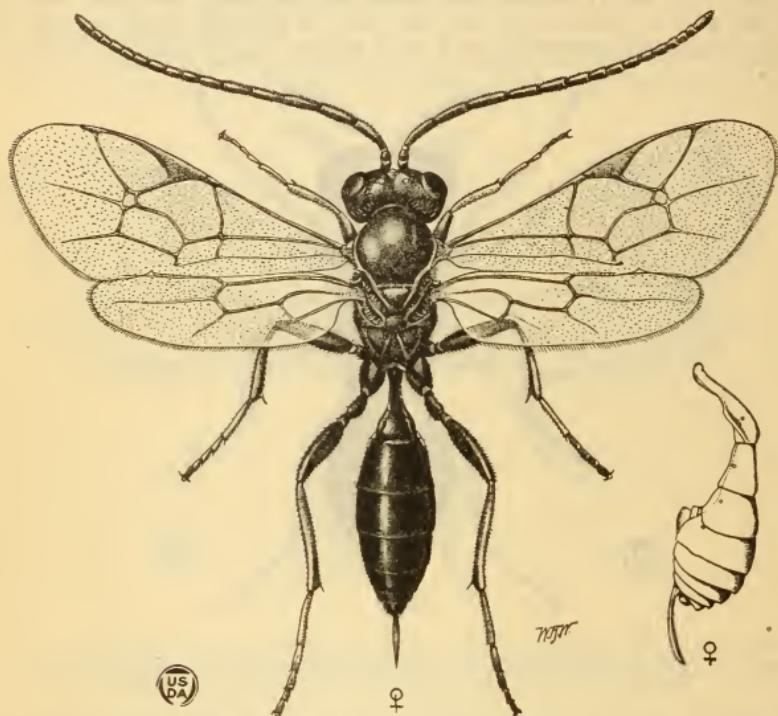


FIG. 4.—*Bathyplectes curculionis*, a parasite of the larva of the alfalfa weevil: Adult female; lateral view of abdomen of same at right. Greatly enlarged. (Webster.)

EFFECTIVENESS OF BATHYPLECTES CURCULIONIS.

It is difficult to say how much of the improvement in the alfalfa crop which has accompanied the increase of the parasite can be attributed to *Bathyplectes curculionis*. Its beneficial effect is probably overestimated by many farmers and others, who now find most of the weevil cocoons occupied by parasites where formerly they contained healthy weevil larvae or pupae. The improvement in the crop can be partly explained by weather conditions in recent years. A 90 per cent parasitism does not lessen the weevil injury to the extent which might be expected; in fact, such parasitism has much

less effect upon the multiplication of the weevil than is commonly supposed.

EFFECT OF THE WEATHER UPON PARASITISM AND THE WEEVIL.

Much of the improvement in the alfalfa crop during the last few years may be amply accounted for by the weather conditions. The parasites were introduced in Utah in the midst of a series of years during which the weather in the weevil-infested territory was warm and dry in the late winter and early spring but cool and damp at haying time, enabling the weevil not only to develop early and rapidly each spring but also protecting it from great mortality due to heat at the cutting of the first crop. Under these conditions the weevil injury was so severe that the first crop was sometimes unfit for use and the second one usually was too late to permit the growth of a third crop.

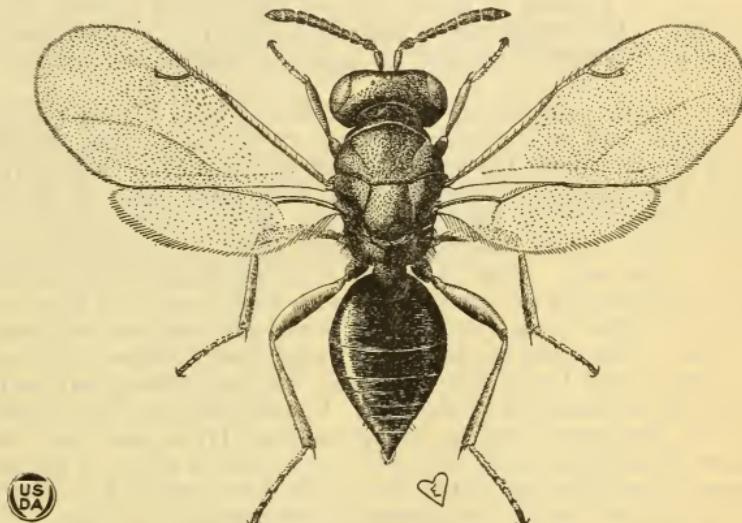


FIG. 5.—*Eupteromalus* sp., a pteromalid parasite of *Bathyplectes curculionis* common in Utah. Greatly enlarged.

By the time the European parasites were numerous enough to be a factor, a series of seasons of opposite character set in and has continued until the present time. Cool, moist spring weather has aided the growth of the alfalfa and slackened the egg-laying of the beetles as well as the feeding of the greatly reduced number of larvae, while clear, hot harvest weather has killed so many larvae that no treatment has been necessary to protect the second crop. In 1917, especially, the weevil injury was insignificant, not only in districts where parasites were well established but also where they were rare or absent, showing that the control was more or less independent of them.

EFFECT OF PARASITISM UPON FEEDING.

Although the parasite is so prolific as to kill 90 per cent of the weevil larvae, it does not thereby prevent 90 per cent of the damage to the crop because the parasitized weevil larvae, in spite of their condi-

tion, accomplish about two-thirds of the normal amount of feeding, according to laboratory observations, before stopping to spin their cocoons. While this amount of feeding may not be sufficient to ruin a crop in a lightly infested field, in some cases it would be quite enough, as has been shown by fields in which one-third of the larvæ have been killed by spraying.

EFFECT OF PARASITISM UPON INCREASE.

Before the parasites became numerous, it was observed that for several years after the weevil is first noticed in any locality it increases at a tremendous rate, but that after the third or fourth year the insect is apparently taken under control by natural influences and ceases to increase. According to egg-laying records of weevils kept in the laboratory, the potential annual increase is not far from 400 to 1. It follows that natural control depends upon the removal in one way or another of about 99.8 per cent of the females of each generation. Unfortunately, before this condition is attained, the weevils are numerous enough to produce destructive numbers of larvæ.

These natural controlling factors include winter killing and summer killing, and it is largely because of the latter that the effect of this parasite upon the reproduction of the weevil is greatly reduced. The summer killing in large part takes place at the time of the cutting of the first crop, when larvæ are exposed to the hot dust, and in hot and dry weather about 90 per cent are removed in this way. This mortality is independent of the parasites and takes place just as surely without as with them, and their work is largely wasted upon victims that would not produce offspring in any event. This goes far to explain why *Bathyplectes* can destroy 90 per cent of the larvæ year after year without causing any marked decrease in the numbers of the pest. Considering this fact, together with the continued feeding of parasitized larvæ and the recent weather conditions, there may still be doubt, in spite of the great numbers of existing parasites, that these have caused the improvement in the crop which has generally been credited to them. When circumstances favor the development of the weevils rather than the alfalfa, and the insect is permitted by climatic conditions to develop its attack as formerly, the value of the parasites will be subjected to a true test. Until then they must be counted a potential safeguard to be studied with a view to increasing their usefulness, while other means are relied upon to protect the crop.

MINOR PRIMARY PARASITES.

Besides the five parasites the importation of which has been outlined, four other species of less importance have been released but apparently have not become established, presumably because it is not known how to provide them with proper living conditions. These are *Spintherus* sp.?, *Bathyplectes corvina* Thoms., *Spilocryptus pumilis* Kriechb., and *Hemiteles graculus* Grav. Another imported cryptine has been recovered in Utah, but it was probably present there before its importation was attempted by the Bureau of Entomology. In Utah, as well as in Europe, it is a parasite of minor importance.

SUMMARY AND CONCLUSIONS.

Twelve species of parasites of the alfalfa weevil have been brought from Europe into the United States and ten of them have been liberated in Utah. Five of these have shown promise of practical usefulness. One of the five, *Bathyplectes curculionis*, has become established in this country and has spread so rapidly that it has overtaken the weevil, which started to spread from the same point about 10 years earlier.

The parasite *Bathyplectes curculionis* has increased in numbers until it now actually swarms in the infested fields of Utah and destroys over 90 per cent of the weevil larvae in the older sections, much surpassing its effectiveness in any of the localities studied in Europe at the time of the importations, where the highest local average of parasitism by all the species of parasites which attacked the larvae was 12.5 per cent.

Any estimate of the value of *Bathyplectes curculionis* to the farmer would be premature at present, but in comparison with other cases of insect parasitism its hardiness and fecundity make it very promising, especially if its work can be supplemented with that of other parasites.

Other promising species of parasites have failed to become established, in some cases because their needs were not well understood before they were imported. With that difficulty removed by further study, they might be made to do for the other stages of the weevil what *Bathyplectes* has done for the larvae.

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